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In reply refer to:  
PS-10391-104  
28 February 1995

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FEB 1 1995

FOOTBALL ROOM

Federal Communications Commission  
Room 222 - Mail Stop 1170  
1919 M Street N.W.  
Washington, D.C. 20554

Attention: William F. Canton  
Acting Secretary

Reference: ET Docket 94-124: RM 83038  
Use of Radio Frequencies Above 40 GHz for New Radio Applications

Gentlemen:

AEL Industries, Inc. (AEL) herewith submits the original and four (4) copies of the enclosed "Reply Comments" for filing with the commission in the above referenced proceeding.

Should you have any questions, please contact the undersigned at (215) 822-7272, Extension 2221; or Fax at (215) 822-8432.

Very truly yours,



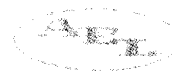
Patrick Shea  
Manager of Contracts  
AEL INDUSTRIES, INC.  
Microwave/Antenna Division

Enclosure

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Filed of the Commission  
FEB 1 1995

**AEL Industries, Inc.**

FILED



FEB 1 1995

27 February 1995

COMMUNICATIONS

Before the  
Federal Communications Commission  
Washington, DC 20554

In the Matter of

ET Docket No. 94-124  
RM-8308

Amendments of Parts 2 and 15 of the  
Commissions Rules to Permit Use of  
Radio Frequencies Above 40 GHz  
for New Radio Applications

### **REPLY COMMENTS OF AEL INDUSTRIES, INC.**

AEL Industries, Inc. hereby submits its reply comments in response to the Notice of Proposed Rulemaking (NPRM) issued in the above-captioned proceeding. AEL's reply is directed at maintaining LMDS at 27.5 - 29.5 GHz and show that LMDS at 40.5 - 42.5 GHz is not feasible.

#### **1.0 INTRODUCTION**

AEL Industries is a leading supplier of state-of-the-art advanced technology millimeter wave antennas, receivers and transmitters for military as well as commercial applications with over 15,000 subsystems deployed throughout the world.

In this capacity, AEL is experienced with the technology and cost issues associated with development, manufacturing and fielding operational millimeter wave hardware.

AEL is supportive of opening up millimeter wave frequencies above 40 GHz for commercial development, however we firmly support maintaining terrestrial Local Multipoint Distribution Service (LMDS) at 27.5 to 29.5 GHz. The increases in path loss, rain attenuation and component loss and complexity make LMDS at 40 GHz impractical and not economically feasible.

## 2.0 BACKGROUND - UNDERSTANDING LMDS

Figure 1 shows a typical implementation for a 28 GHz LMDS system. The coverage sector consists of a number of transmit sites (cells) with a maximum transmit range of 5 km. Each transmitter has the ability to transmit up to 50 video/audio channels to any home receiver within the cell. FM modulation is used to achieve carrier-to-noise enhancement and minimize transmitter cost. Each channel occupies 20 MHz of spectrum for 1 GHz total. The base band signals are upconverted and amplified to 27.5 to 28.5 GHz. The remainder of the spectrum is used for interactive communications with the home sites. A high power TWT amplifier (TWTA) is used to amplify the signals to the desired transmit level (26 dBm/0.4 W per channel). (Solid state amplifiers could be used instead of TWTAs, however, 20 one watt linear devices would be required to achieve the same output power per channel.) All fifty channels are radiated through a single antenna. The antenna has omnidirectional azimuth coverage and a shaped elevation beam to provide signal to all users within the cell while minimizing interference with satellites or airborne platforms. Figure 2 shows typical transmit antenna coverage. Notice, the low sidelobes ( $< -23$  dB) in the sky direction (zenith  $\pm 60^\circ$ ).

The receiver antenna has a high gain pencil beam to link it directly with the transmitter site without interference with other subscribers or operating systems. The received signal is downconverted and demodulated to provide up to 50 channels of video to the home user.

Table 1 shows a link budget for 28 GHz system. The major factors associated with performance are transmit power per channel, antenna gain, free space path loss, atmospheric attenuation, rain attenuation, receive antenna gain and receiver noise figure and IF bandwidth.

**Table 1. 28 GHz LMDS Link Budget**

Transmit Power-Per-Channel (50 Channels)	25 dBm (0.3 W)
Transmit Antenna Gain	12 dB
Range	5000 Meters
Free Space Path Loss (5 km)	135.4 dB
Atmospheric Attenuation	Negligible ( $< 0.5$ dB)
Rain Attenuation [1, 2] (@ 15mm/hr)	13 dB
Receive Antenna Gain	32 dB
IF Bandwidth	18.6 MHz
Receiver Noise Figure	6 dB
Carrier-to-Noise-Ratio	16 dB
Picture Quality	4

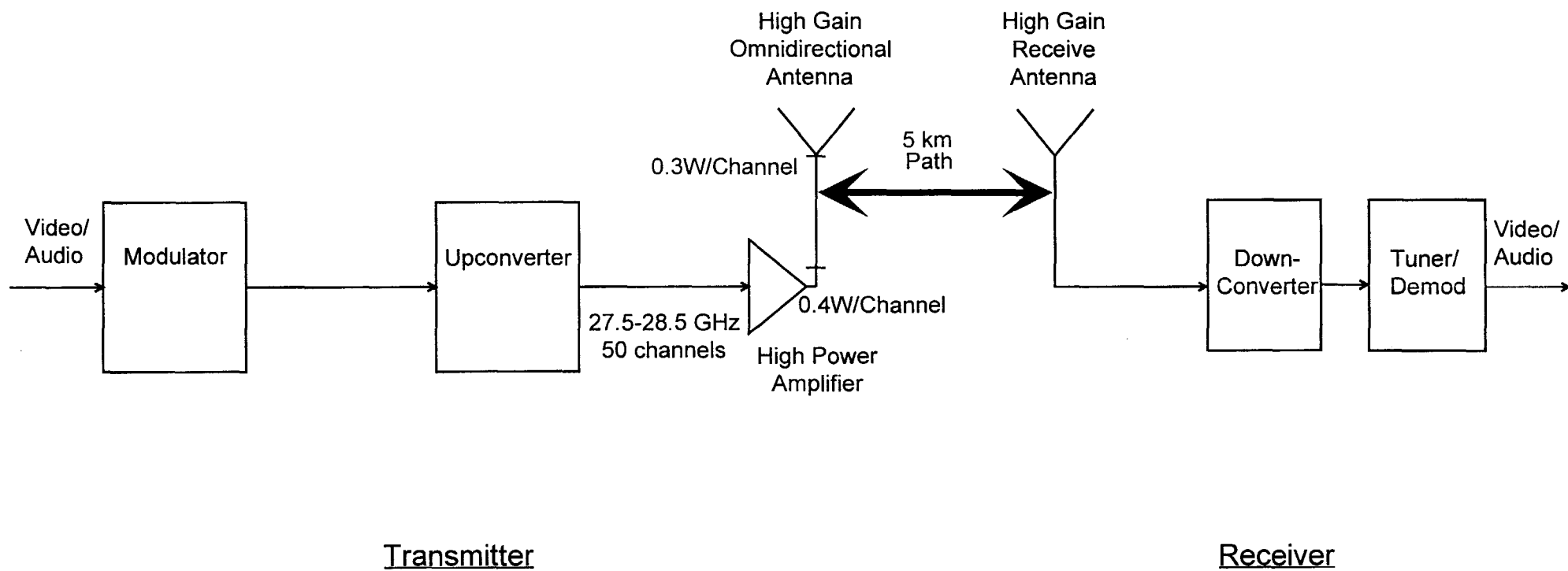


Figure 1. LMDS Functional Block Diagram

# Typical Coverage

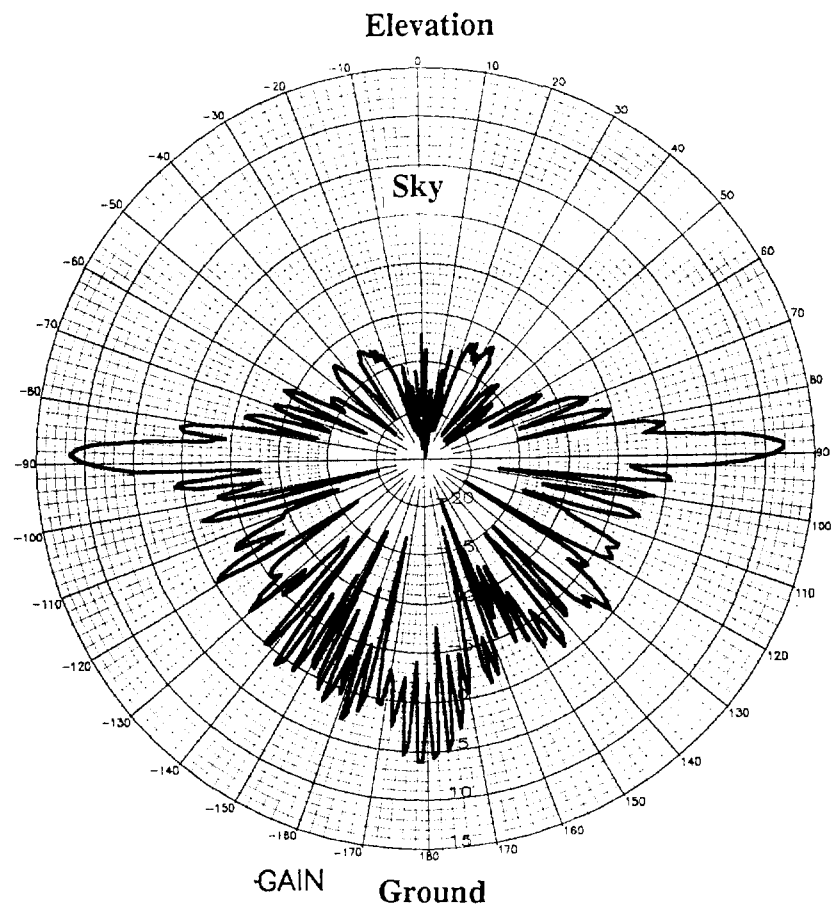
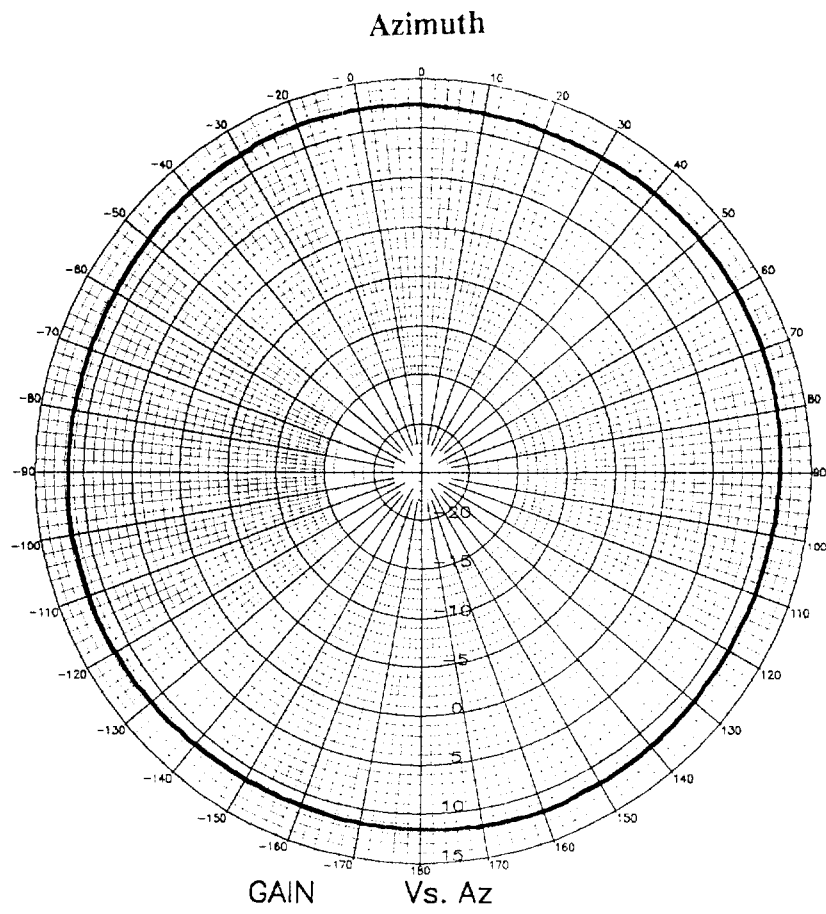


Figure 2. LMDS Transmit Coverage

The parameters were selected based on available component technology and proven performance in the field as experienced by CellularVision in their New York sites. Deviation from these parameters will produce carrier-to-noise ratios below the level acceptable for quality video. Unlike the European Multipoint Video Distribution Service (MVDS), the goal of this system is to produce picture quality ratings approaching four with a worst case rain availability of 99.9% throughout the entire United States since critical telephony and data services will be provided.

### **3.0 LMDS AT 41 GHz**

As discussed in Section 2, LMDS systems at 28 GHz have been configured to provide good picture quality at an economically viable cost. The quantity and complexity of hardware is minimized through the selection of a TWT transmitter architecture and 5 km radius cells. *LMDS at 41 GHz is not equivalent to LMDS at 28 GHz.*

To achieve the same performance at 41 GHz as 28 GHz requires an increase in hardware, power and/or frequency spectrum. It is AEL's belief, that the costs associated with these increases will severely limit LMDS viability. Table 2 shows a comparison of link margins for the 28 GHz system and three 41 GHz systems. The basic building blocks as shown in Figure 1 still apply. The first case examined (Example A) shows that there will be a 22 dB carrier to noise ratio degradation in the LMDS system at 41 GHz. This is unacceptable for a quality video system. This is directly attributable to a 3.5 dB decrease in transmitter power due to transmitter inefficiencies at 41 GHz, 3 dB increased path loss, 13.5 dB increase in rain attenuation [2] and a 2 dB increase in receiver noise figure.

The majority of the loss increase 13.5 dB, is due to rain attenuation. It has been suggested that this can be overcome by decreasing the rain availability below 99.9%. This is not possible because of the need to provide local alternative services.

It is possible to achieve equivalent performance at 41 GHz at the sake of drastically reduced cell coverage or increases in transmitter power. But this is not economically viable.

The two examples "B" and "C" shown in Table 2 demonstrate these conditions. Example B shows that a similar quality signal can be had at 41 GHz with a decreased 2161 meter cell path. Thus, to perform the same function for a given area at 41 GHz would require at least five times the number of cells as a system at 28 GHz. Given the enormous cost of each transmitter site, this would make LMDS not economically viable.

**Table 2. LMDS Link Budget Comparison**

	<b>28 GHz</b>	<b>(A) 41 GHz</b>	<b>(B) 41 GHz</b>	<b>(C) 41 GHz</b>
Transmit Power Per Channel (50 Channels)	25 dBm (0.3 W)	21.5 dBm	21.5 dBm	44 dBm
Transmit Gain	12 dB	12 dB	12 dB	12 dB
Range	5000 Meters	5000 Meters	2161 Meters	5000 Meters
Free Space Path Loss	135.4 dB	138.7	131.4	138.7
Atmospheric Attenuation	Negligible (<0.5 dB)	Negligible (<0.5 dB)	Negligible (<0.5 dB)	Negligible (<0.5 dB)
Rain Attenuation [1, 2] (@ 15mm/hr)	13 dB	26.4 dB	11.41 dB	26.4 dB
Receive Gain *	32 dB	32 dB	32 dB	32 dB
IF Bandwidth	18.6 MHz	18.6 MHz	18.6 MHz	18.6 MHz
Receiver Noise Figure	6 dB	8 dB	8 dB	8 dB
Carrier to Noise Ratio	16 dB	-6.5 dB	16 dB	16 dB

Example C shows another alternative. The cell path is kept at 5 km and the transmitter power is increased to overcome the increased losses. To do so would require an individual (25W) TWT for each channel and this obviously is not practical.

One final method, increasing the transmit antenna gain, has been evaluated to compensate for the increased losses at 41 GHz. A 3 to 8 dB improvement in antenna gain could be realized but at the expense of coverage and frequency spectrum.

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\* It is not practical to increase the receive gain at 41 GHz. The reason lies in keeping the beamwidth about the same as has been demonstrated at 28 GHz to maintain: a) A beam wide enough to permit stable pointing at low cost and 2) To keep the beamwidth wide enough to permit reliable reception during the normal multipath of the urban environment and the additional scintillation effects of phase and amplitude changes during rain. This gain is consistent with the receive gain as defined for MVDS [3] and used by CellularVision in their New York site.

As discussed in Section 2 and shown in Figure 2, the current transmit antenna coverage has been optimized to provide maximum coverage in a 5 km radius cell. A gain increase requires that the antenna beamwidth be reduced proportionally. In a 5 kilometer radius cell, as the elevation beamwidth is decreased 50% to provide 3 dB additional gain, there will be coverage outages within the cell. This is unacceptable from an availability viewpoint and can only be overcome by reducing the cell size proportional to the beamwidth reduction.

The transmit gain can also be increased by reducing the azimuth beamwidth through a sectorized approach. For a six sector system an 8 dB improvement in gain is possible due to a reduction in beamwidth from 360 degrees to 60 degrees. The consequence of this action is that each sector must radiate 50 channels noncoherently. If the sectors are coherent, each at the same frequency, the azimuth coverage will be the array pattern of all six sectors combined. As shown in Figure 3 this results in an interferometer pattern with many nulls resulting in many areas of severe coverage outages. This can be overcome by allocating each sector its own frequency spectrum but this would require 6 GHz of bandwidth. In addition, to overcome excess rain attenuation each sector would be required to have its own high power transmit amplifier. This extra cost makes LMDS not economically viable at 41 GHz.

The other option is to use expensive time multiplexing, modulation and encryption techniques to eliminate the coherency between sectors. This drastically increases the cost and complexity of the home receiver as well as each transmitter for only an 8 dB improvement.

#### **4.0 CONCLUSION**

Based on the analyses presented and in the best interest of the consumer it is AEL's position that the commission should institute LMDS at 28 GHz. LMDS at 41 GHz is not a viable system.

#### **REFERENCES**

- [1] Crane, R.K. "Prediction of Attenuation by Rain", IEEE Trans. Comm., Vol. Com-28, No. 9, pp 1717-1732, 1980.
- [2] Ippolito, L.J., Propagation Effects Handbook for Satellite Systems Design, NASA Reference 1082(04), Feb 1989.
- [3] Report of the 40 GHz MVDS Working Group, UK Radio Communications Agency, November 1993, Appendix F.



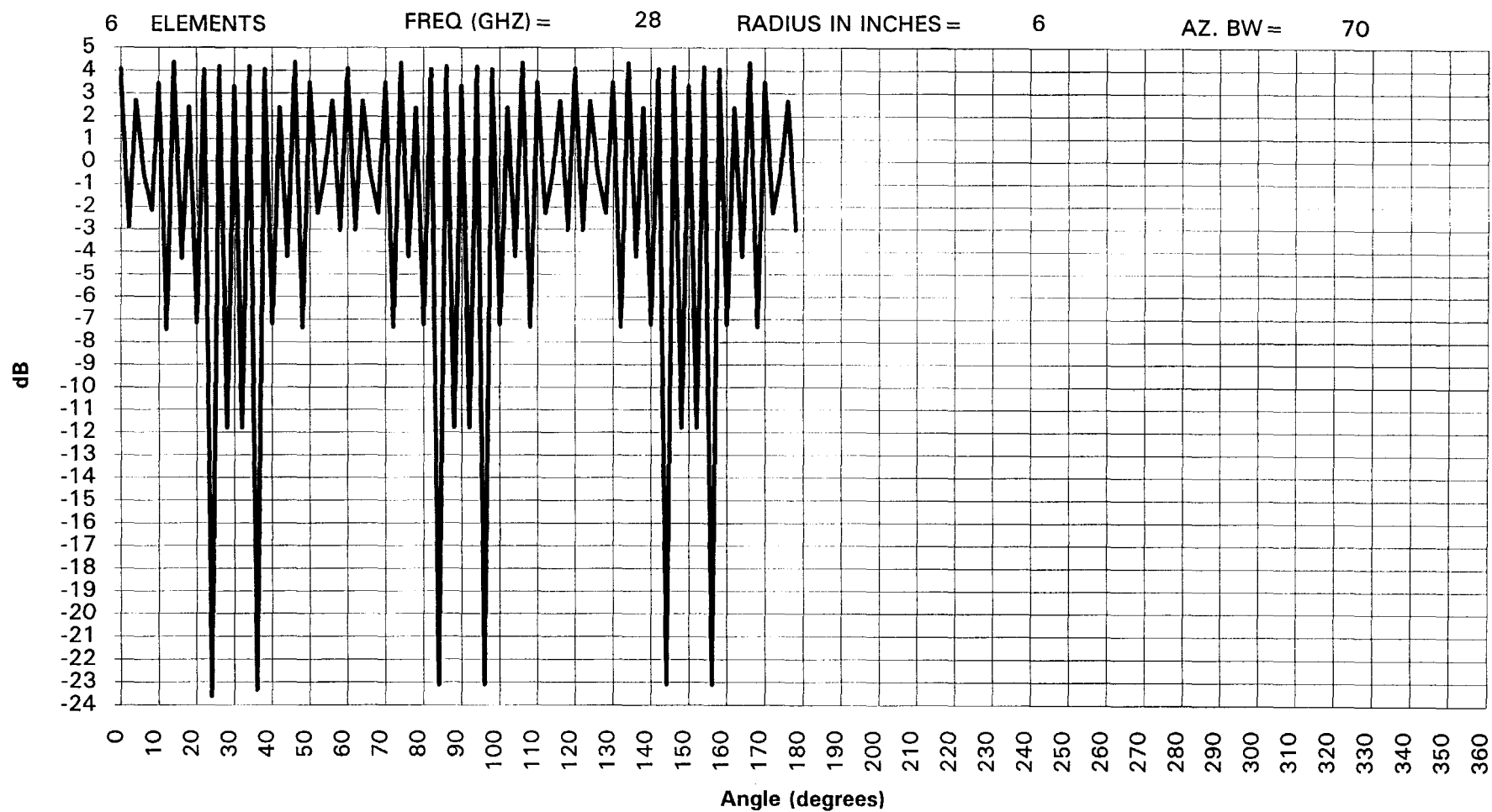


Figure 3. Azimuth Coverage, Forward Hemisphere, Six Sector Coherent LMDS System